From Russia with love: the impact of relocated firms on incumbent survival

Journal of Economic Geography (2012) pp. 1–31 doi:10.1093/jeg/lbs035

From Russia with love: the impact of relocated firms on incumbent survival

Oliver Falck, Christina Guenther**,***, Stephan Heblich**** and William R. Kerr*[†,‡,§]

*Ifo Institute, University of Munich and CESifo, Poschingerstr. 5, 81679 Munich, Germany
**Max Planck Institute of Economics, Evolutionary Economics Group, Kahlaische Straße 10 07745 Jena, Germany
***WHU-Otto Beisheim School of Management, Burgplatz 2, 56179 Vallendar, Germany
****University of Stirling, IZA and SERC, FK9 4LA Stirling, United Kingdom
[†]Harvard University, Bank of Finland, Rock Center 212, Harvard Business School, Boston, MA 02163, USA
[‡]NBER, 1050 Massachusetts Avenue Cambridge, MA 02138, USA
[§]Corresponding author: William R. Kerr. *email* <wkerr@hbs.edu>.

Abstract

We identify the impact of local firm concentration on incumbent performance in a historic setting that has quasi-experimental characteristics. When Germany was divided after World War II, many firms in the machine tool industry fled the Soviet-occupied zone to prevent expropriation. We show that the regional location decisions of these firms upon moving to western Germany were driven by non-economic factors and heuristics rather than existing industrial conditions. Relocating firms increased the likelihood of incumbent failure in destination regions, a pattern that differs sharply from new entrants. We further provide evidence that these effects are due to increased competition for local resources.

Keywords: Agglomeration, competition, firm dynamics, labor, Germany
JEL classifications: R10, L10, H25, O10, J20
Date submitted: 23 November 2011 **Date accepted:** 30 August 2012

1. Introduction

A common theme in economic geography is that increasing returns to scale at the local level are essential for explaining the geographical distribution of economic activity. Many industries have product markets that are national or international in scope and one typically finds the firms of those industries tightly clustered together in specialized regions or clusters (e.g. automobiles in Detroit, finance in London). These geographic agglomerations of similar firms offer benefits to each member firm by reducing the transportation costs for material goods, specialized workers and industry knowledge among the firms. Increasing returns are further generated through shared local inputs, indivisible facilities, better matching possibilities due to thicker markets and so on.

Of course, tight geographic concentration comes with countervailing costs as firms compete for local inputs. This competition is most frequently expressed in rental prices and wage rates that differ both across local areas and across districts within a specific region. With this pricing, it is not certain that the increased benefits to incumbents from additional firm concentration will maintain pace with growing input costs or

vice versa. The effect of increased local agglomeration on incumbent firm performance is thus ambiguous. In the extreme, greater competition for scarce local inputs can force some incumbent firms out of business even when product markets are very broad in scope.[1]

This article investigates the impact of increased local concentration on incumbent firms. Causal identification in this setting is quite challenging due to selection effects. Economic models typically begin with rational entrants that form expectations about the relative costs and benefits of locations and choose the best candidate. This location choice process suggests that empirical correlations of changes in local firm concentration and incumbent firm performance or survival are likely to be biased from the true relationship. For example, high entry rates may reflect short-term spatial disequilibria with favorable benefit/cost ratios that can independently promote incumbent firm performance and survival and the adverse impact of new entrants on input conditions for local incumbents is likely to be dampened in these opportunistic settings.

This endogeneity problem can be overcome with random assignment of locations to entrants. One situation in which location choice is as good as random arises when the entrant has incomplete information about locations. The entrant will first use available information to limit the choice set of potential locations. However, after removing weak contenders, the entrant will be indifferent among observationally equivalent locations and hence choose randomly among the finalists. This idea drives the identification strategy in the pivotal work of Greenstone et al. (2010), who analyze the effect of opening a large manufacturing plant on the productivity of incumbent firms in the local region. In their setting, the location choice for a new plant by an expanding firm begins with a detailed review of dozens of possible locations. This review process, however, yields several top candidates that are often very difficult to choose among. This ambiguity makes the final location decision effectively random among these top candidates.

A second setting that overcomes the selection bias is where location choice is driven by non-economic factors. If decisions are made exclusively according to factors that are orthogonal to local industrial conditions and future perspectives, the assignment of entrants can be treated as random for incumbents. Such quasi-experimental variation is rare in regional economics and cannot be generated in controlled experiments (Holmes, 2010). This form of variation is very valuable, however, as randomized location choices are over all potential sites. When relying on economic decisions based upon substantial but ultimately incomplete information, as exemplified by Greenstone et al. (2010), tight comparisons are made amongst the best sites for an entrant. In principal, decisions due to non-economic factors and/or extremely limited information offer a wide spectrum of sites that include (from a local business perspective) very good choices and very bad choices.

1 Marshall (1920) first outlined many of the rationales for industrial agglomerations. Duranton and Puga (2004) and Glaeser (2008) document the microeconomic foundations of agglomeration economies, and Rosenthal and Strange (2004), Boschma and Frenken (2011), and Combes et al. (2011) study the corresponding empirical evidence and identification challenges. Rosenthal and Strange (2001, 2003) and Ellison et al. (2010) provide recent empirical analyses of the relative strengths of agglomeration forces, Dauth (2011) considers agglomeration forces in Germany specifically and Gardiner et al. (2011) provide a broader European study. Combes et al. (2010) provide recent evidence on the costs with agglomeration. This paper also relates the work of Javorcik (2004) and Greenstone et al. (2010) on the entry of major plants into local areas.

This article exploits a historical setting with quasi-experimental characteristics—the division of Germany into four occupational zones after World War II. By 1949, the three western zones occupied by England, France and USA formed the Federal Republic of Germany. The eastern part developed into a satellite state of the Soviet Union and most believed in 1949 that this eastern zone would adopt the Soviet Union's socialist system. The fear of expropriation (or worse) prompted many firm owners to flee to western Germany. They left most if not all of their physical assets behind, re-registered in West Germany and used their experience and reputation to re-build their firms.

We study this relocation in the context of the machine tool industry. Our data catalogue the entire population of German firms in the machine tool industry from 1949 onward, along with many pre-war conditions. This industry is a good setting for investigating localized agglomeration and input competition effects. The industry's product markets are international in scope, but its production processes benefit from agglomeration economies due to specialized knowledge and workers, exchanges of material goods and similar. The industry is characterized by strong manufacturer–user relationships that are the main impetus of innovation in this industry, and it largely consists of small- and medium-sized firms. While comprising 2% of German industrial production, the machine tool industry is an important foundation for the broader metalworking sector.[2]

Moreover, the relocation of the machine tool industry from eastern to western Germany was quite substantial. We identify 33 relocators that fled from the Soviet zone to the American or British occupation zones. These 33 firms represent an 8% increase in total industry size for receiving zones. The localized increases ranged from 0% to 200% for regions, with an average of 11% for regions experiencing a relocation. In total, a fifth of the machine tool industry present in eastern Germany migrated during a narrow window of 1949–1956. This was a one-time event, as no comparable prior or subsequent migrations occurred within the industry across German regions, eastern or western.

Using conditional logit frameworks, we first show that these location choices were made with very little regard to existing business conditions across regions in western Germany. The general destruction of Germany during World War II, the displacement of millions of people within West Germany, heavy production bans and Germany's division arguably resulted in very little information, much less accurate information, about the current state of regions and especially their future prospects. Moreover, many migrations were made under extreme duress. Consequently, relocating firms did not undertake sophisticated location decisions, but instead based their destination choices on heuristics and non-economic factors. In particular, we show that greater cultural similarity and further geographic distances dominate economic factors in these decisions.

Yet, upon arrival, these relocating firms substantially impacted local industrial conditions as the firms quickly regained much of their former production capacity (Buenstorf and Guenther, 2011). On an average, they survived >30 years at their new locations. We use hazard models to compare incumbent survival by region based upon the magnitude of this influx. We find that relocations significantly increased the

2 See Sciberras and Payne (1985), Ashburn (1988), Carlsson (1989), Lee (1996), Hirsch-Kreinsen (2000) and Arnold (2003).

likelihood of incumbent failure, which suggests that the costs of increased competition for local inputs exceeded the potential benefits from agglomeration economies. By contrast, we find that new start-up entrants during the post-war period—whose location choices were more opportunistic—were not associated with increased incumbent failure rates. These differences provide additional confidence in our experimental design.

Finally, we further validate the resource constraint hypothesis by examining local workforce conditions after the war. In particular, western Germany experienced a contemporaneous inflow of about 8 million expellees who were distributed across local regions by means of allocation schemes implemented by the authorities of the zones of occupation. These expellees were critical for rebuilding a German workforce devastated by the war. These expellee assignments were mostly orthogonal to the existing machine tool industry. As such, there exists great heterogeneity in workforce conditions across locations where relocations of machine tool firms occurred. We show that the increased failure rates of incumbents in western Germany due to relocating firms was concentrated in regions where labor forces were constrained due to low expellee inflows. In regions with a significant inflow of expellees and favorable input conditions, there was no effect of relocations on incumbent firms' risk of failure.

Our study's focus on a historical setting with quasi-experimental characteristics allows us to identify the causal effect of relocated firms on incumbent survival for the machine tool industry in post-war Germany. The agglomeration and competition forces for the machine tool industry during the period we study are representative to those of producers of highly specialized input goods. Machines were tailored to users' needs and as a result, there were often a limited number of customers worldwide for one specific machine tool. Thus, the findings of this study are most directly applicable to situations where an international product market exists, input constraints are localized, firms have heterogeneous productivities and products require some degree of customization.

With any historical study, however, natural questions arise as to the external validity of the results. In our case, it is important to note that relocating firms are probably not comparable to the average East German firm before the war; likewise, incumbent firms in West Germany are probably not comparable to the average West German firm before the war because they all survived the war and post-war production bans. While these important considerations limit the extent to which we focus on the magnitude of a single elasticity estimate or hazard rate for out-of-sample predictions, they do not limit this study's main point that exogenous increases in firm density around incumbents can be detrimental depending upon whether the heightened benefits of increased agglomeration compensate for rising costs the incumbent firms face or not. While sometimes the benefits exceed costs, they did not for the machine tool industry in post-war Germany. As we discuss further in the conclusions, this is an important consideration for regional planners considering whether and how to attract migrating firms to their local areas.

The remainder of the article is organized as follows. Section 2 describes the quasi-natural experiment in greater detail and Section 3 introduces the German machine tool industry. Section 4 analyzes the location choices of relocating firms, Section 5 examines the impacts of relocating firms for incumbents and Section 6 concludes the article.

2. Industrial relocation from the Russian zone as a natural experiment

After World War II, Germany was initially separated into four occupational zones that were independently administered by France, UK, USA and the Soviet Union. In the years following World War II, differences in ideology between the three 'western' administrations and the Soviet Union led to a second, lasting separation of Germany. The western part evolved into a federal parliamentary republic with a market-oriented economy and the socialist eastern part adopted the Soviet system of a planned economy. The partition became quasi-official in May 1949 when the three western zones were merged into an independent state, the Federal Republic of Germany (West Germany) and the Soviet zone became the German Democratic Republic (East Germany) in October 1949. Even though the West German Constitution considered the two-state solution as an artificial status quo, reunification was not expected in the short term. To this end, West Germany began massive investment in developing the infrastructure and housing supply for its new capital of Bonn.

As it became clear that the separation was semi-permanent and that East Germany was adopting a Soviet system, many East Germans looked west in search of political freedom and economic prosperity. More than 2.5 million people fled East Germany to resettle in West Germany during the late 1940s and 1950s, prior to the construction of the Berlin Wall in 1961. Among the refugees were thousands of business owners whose firms were threatened with socialization. Recognizing the costs of these firm migrations, East Germany continually strengthened border controls to prevent a large-scale outflow of productive capital and knowledge, and thus most business relocations were secretly planned and quickly executed. As a consequence, it was impossible for these owners to collect or analyze detailed information about potential locations in West Germany. Moreover, available information had very little content for decision making due to vast destruction during World War II and the subsequent dismantling of many undestroyed production facilities (Laske, 1995; Mazzoleni, 1997). For most decisions, even existing industrial structures were simply not known, much less the future prospects of a region.[3]

The expropriation and dismantling of machine tool producers in the Soviet zone was largely based on a referendum held on 30 June 1946. The referendum approved the expropriation of all Nazis and war criminals, a group that included firm owners who engaged in or were related to the production of armaments. Given that the whole machine tool industry was somehow involved in the production of armaments, most owners were subsequently expropriated and their firms were socialized. In this environment, firm owners who chose to flee were unlikely to relocate many of their physical assets. Instead, they relied on their intangible assets, i.e. knowledge about existing products, experience in their production techniques, and the firm's name and

3 Histories of the machine tool industry and its trade associations suggest that moderate information exchange occurred between companies in the future East Germany and their Western counterparts before the war. This information exchange occurred through product catalogues, technical fairs and journals, and similar. The board of the primary trade association included members from around the country, as the German firms sought a unified voice in public matters (e.g. trade policy). We have not, however, identified evidence of formal links between these groups through multi-unit plants, spin-off activities or similar.

reputation. Despite losing a large part of their physical assets, the intangible assets helped business owners to quickly restart their firms in West Germany (Buenstorf and Guenther, 2011).

Two case studies of machine tool producers originally located in the Chemnitz region of East Germany illustrate the setting. In response to the expropriation threat, the owners and managers of the Wanderer Corporation called an extraordinary general meeting in Munich where they decided to relocate the company to that city. This was done quickly, and the company continued producing milling machines and related products at their new location from 1949 onward. Pfauter Co. was a producer of machine tools used in gear production that was established in Chemnitz in 1900. At the end of the war, the firm was being run by the founder's four sons. Feeling threatened by the Soviet occupation, three of the Pfauter brothers and some loyal employees moved the company to Stuttgart in 1949 and re-established it. The fourth brother was detained by the Soviets (Buenstorf and Guenther, 2011).

All together, the separation of Germany was a hard blow for the machine tool industry. Prior to World War II, almost 30% of Germany's machine tool manufacturers were located in the eastern part of Germany that was to become the Soviet zone after the war. This separation of the former centers of the industry, especially around Chemnitz, Leipzig and Dresden in Saxony, as well as East Berlin, resulted in a 41% reduction of production capacity as compared to 1938 (Schwab, 1996).

3. The German machine tool industry

Machine tool producers are defined as producers of power-driven machines that are used to produce a given work piece by cutting, forming or shaping metal (Wieandt, 1994). The industry emerged in the 1800s near its initial customers in the textile and metal processing industries. At that time, demand was local and knowledge transfers from customers were important. By the 1900s, the industry had evolved to be export-oriented with limited ties to local demand. In 1913, Germany was the world's largest exporter of machine tools, with a value of US$176 million compared to the US' exports of US$162 million (Labuske and Streb, 2008). Richter and Streb (2011) describe the sophisticated and innovative nature of the industry in the pre-war period. The industry exported 48% of its total production during 1954–1963 (Buenstorf and Guenther, 2011), after which exports grew to typically account for >60% of West German output.

Despite its sensitive connection to war equipment machinery noted earlier, the machine tool industry was built upon a much broader product base both before and after World War II. Prior to World War II, Schwab (1996) highlights that production during the interwar period was dominated by general purpose machinery, although special purpose machines were produced mainly for munitions production. In the 1950s, ~80% of the machine tools were sold to the capital goods industry, especially the automobile, electrical engineering, machinery and steel industries.[4]

4 In terms of specific products, turning machines and lathes constituted almost 25% of production in 1950, followed by milling, sawing and filing machines (11%); grinding machines (10%); drilling, boring and threading machines (8%); planning, slotting and broaching machines (8%); presses (9%); and wire making and forming machines (7%). Other product groupings included universal tools; transfer lines; other metal cutting tools; keyseating machines; gear hobbing and shaping machines; finishing machines;

Due to this broader base, the industry experienced substantial growth during our period of study. The immediate post-war constraints on production were eased in 1949 and thereafter production in the industry grew ~3-fold in real terms to 2000. This strong growth was supported by reanimated consumption and investment (Henning, 1993). Moreover, the reconstruction of Europe's manufacturing industries was a major contributor to the sector's growth as machinery was badly needed (Arnold, 2003). Growth persisted after reconstruction due to strong productivity growth, low inflation, advantageous fixed exchange rates, domestic investments in the sector and a valuable international reputation for high precision and quality engineering (Ifo, 1997).

Our data come from the buyer's guide *Who Makes Machinery* (*Wer baut Maschinen*), which has been issued annually since the 1930s by the Association of the German Machine Tool Producers (*Verein Deutscher Maschinen- und Anlagenbau*, various years). This source allows identification of the entire firm population of 2267 machine tool producers in West Germany from 1949 to 2002.[5]

Based on the 1936–1943 volumes of *Who Makes Machinery*, we identify 394 incumbent firms with pre-war experience in the British or American zones. Our focus on these two occupational zones is due to much weaker dismantling of incumbent production facilities that can impact our survival measures. Whereas 99 and 70% of 1938 production value was affected by planned dismantling after the war for the French and Soviet occupation zones, respectively, the comparable figures for the American and British sectors were just 16 and 28% (Schwab, 1996). Unfortunately, we have not been able to collect information on spatial variation in dismantling within each zone.

The first three columns of Table 1 provide statistics for these incumbents by region within each occupational zone. The listed regions are officially defined as 'planning regions'. These regions are functional economic units formed on the basis of commuter distances. Many agglomeration forces find their strongest expression at this geographic level, making this spatial unit ideal for our analysis.[6] The average number of incumbents in the 40 regions was 10, with a median of four incumbents. The three largest centers were Düsseldorf, Stuttgart and Bochum/Hagen.

Product counts are our best estimate of firm size (Franco and Filson, 2006; Klepper and Thompson, 2006). We are able to distinguish 36 types of products from three major product classes: metal cutting, metal forming or special purpose machine tools. The average number of product types for incumbent firms in 1949 was 1.7 and the average number of product variants (sub-types of products) was 3.0. The most important product class varied across regions within each zone.

hammers; bending and straightening machines; riveting machines; drawing machines; sheet and plate working machines; pneumatic tools; shears; hydraulic tools for metal forming; accessories and auxiliaries; blanking presses; rolling mills; special purpose machines for pipe manufacturing; special purpose machines for bolt, rivet and nuts manufacturing and other special purpose machinery.

5 Only one catalogue was issued for 1949/1950, and the 1952 catalogue was not archived. We approximate 1952 with conditions in 1951 for our empirical work.

6 See Rosenthal and Strange (2001), Duranton and Overman (2005), Arzaghi and Henderson (2008), Figueiredo et al. (2009), Fu and Ross (2010), Ellison et al. (2010), Kerr and Kominers (2010), and Drennan and Kelly (2011) for related work on spatial distances for agglomeration forces. For recent work on labor markets and agglomeration, see Diamond and Simon (1990), Rotemberg and Saloner (2000), Fallick et al. (2006), Menon (2009), and Overman and Puga (2010). Behrens et al. (2010), Delgado et al. (2010a, 2010b), Desrochers and Leppala (2011), and Glaeser et al. (2010) provide recent theoretical and empirical analyses of local cluster performance.

Table 1. Descriptive statistics for machine tool industry in West Germany and East German relocations

	Incumbents			Relocators from East Germany			New entrants			Region	
	Total incumbent firm count (1)	Products/ variants per firm 1949 (2)	Dominant product class (3)	Total relocator firm count (4)	Date ranges of relocations (5)	Products/ variants per firm 1949 (6)	Total entrant firm count (7)	Number surviving for 5/10 years (8)	Total entrants before 1956 (9)	Population density 1949 (per km^2) (10)	Expellee share of post war workforce (%) (11)
Planning regions in the US occupied zone											
Bremen	1	2/4	Cutting				9	4/3	4	1371	0–10
Rhine-Main	25	1.8/2.5	Cutting	6	1951–1955	1.7/6.3	71	46/31	21	353	10–15
Starkenburg	4	1/2	Cutting				18	10//7	6	239	10–15
Upper Neckar	3	1/1	Cutting	2	1949–1951	1/4	17	6/5	13	292	15–20
Franconia	5	1.8/2.6	Cutting				20	13/11	9	123	15–20
Middle Upper Rhine	7	1.3/2.4	Cutting	1	1949	2/2	24	10/7	6	297	10–15
Northern Black Forest	11	1.5/2.5	Forming				58	30/25	38	141	10–15
Stuttgart	43	2.1/3.6	Cutting	5	1949–1955	1.2/1.6	136	86/57	56	407	20–25
Eastern Wuertemberg	2	1.5/1.5	Cutting				13	8/6	9	142	20–25
Bavarian Lower Main	2	2/2	Forming				15	10/7	4	173	10–15
Wurzburg	1	1/1	Cutting				5	5/3	2	131	15–20
Upper Franconia-W.	5	1.2/2.2	Forming				11	7/6	3	147	20–25
Central Franconia	15	1.4/2.1	Cutting				38	18/11	15	287	15–20
W. Central Franconia	1	1/1	Cutting				13	7/5	13	150	20–25
Landshut	2	2/2	Forming				2	1/1	2	100	25–30
Munich	5	2/3.6	Cutting	1	1951	3/5	47	24/18	11	278	20–25
Danube-Iller (BY)	1	1/5	Cutting				17	9/8	7	131	25–30
Allgaeu	2	1/2	Forming				11	7/6	3	103	20–25

(continued)

Table 1. Continued

	Incumbents			Relocators from East Germany			New entrants			Region	
	Total incumbent firm count (1)	Products/ variants per firm 1949 (2)	Dominant product class (3)	Total relocator firm count (4)	Date ranges of relocations (5)	Products/ variants per firm 1949 (6)	Total entrant firm count (7)	Number surviving for 5/10 years (8)	Total entrants before 1956 (9)	Population density 1949 (per km^2) (10)	Expellee share of post war workforce (%) (11)
Planning regions in the British occupied zone											
Schleswig-Holstein E.	2	1.5/1.5	Forming				9	2/1	8	278	30–35
Schleswig-Holstein S.	1	3/6	Forming				14	11/7	2	150	>35
Hamburg	9	1.4/1.9	Forming	1	1955	1/1	40	25/18	16	2149	0–10
Hanover	4	1.25/2	Cutting				16	8/6	6	261	30–35
Brunswick	5	1/1	Forming	1	1953	1/1	16	8/7	12	205	30–35
Hildesheim	2	1/1	Forming				7	3/3	2	244	>35
Gottingen	2	1/1	Cutting				12	7/7	3	184	25–30
Berlin	20	1.3/2.2	Cutting	1	1955	2/3	97	47/31	56	4464	0–10
Muenster	1	1/2	Cutting	2	1949–1951	1/1.5	10	4/3	4	170	10–15
Bielefeld	8	2.3/4.4	Cutting				42	26/21	15	304	15–20
Arnsberg	2	2/3.5	Cutting				18	7/5	10	138	15–20
Dortmund	7	4.4/12.6	Forming				15	8/5	5	1039	0–10
Duisburg/Essen	3	2.7/5.7	Forming	1	1956	1/1	28	10/6	9	687	0–10
Düsseldorf	102	1.7/3.8	Forming	6	1949–1953	1.5/3.2	237	112/77	128	956	0–10
Bochum/Hagen	37	2.1/3.7	Forming	1	1951	3/3	76	45/30	27	778	0–10
Cologne	20	2.2/4.8	Forming				62	29/17	30	531	10–15
Aachen	10	2.9/5	Forming	1	1949	1/1	18	11/9	7	237	0–10
Bonn	1	1/1	Cutting	1	1951	1/2	5	3/3	5	272	10–15
Siegen	15	2/3.8	Forming				38	29/27	9	175	10–15
Northern Hesse	2	1.5/1.5	Cutting	1	1949	1/4	22	12/7	7	140	15–20
Central Hesse	5	1.8/6	Forming				24	14/10	4	156	20–25
Eastern Hesse	1	1/1	Cutting				1	1/1	1	125	20–25

Incumbent traits describe existing firms in the planning region before the relocations began. Dominant product classes refer to metal cutting and metal forming. Relocator traits describe firms moving from East Germany. Entrant traits describe new start-up firms that are not relocating from East Germany.

We further identify from the earlier records 33 machine tool producers that were originally located in eastern Germany (28 firms) or Silesia/Prussia (5 firms) but relocated their business activities after the war to either the British or American zones. These 33 companies constituted ~6% of the overall firm population in 1938. Furthermore, relocating companies did not differ in terms of the number of products they produced in 1938 from those firms that stayed (Buenstorf and Guenther, 2011).[7]

Columns 4–6 of Table 1 describe relocators' destination regions, their years of relocation and the number of products that they start with at their new location. All relocations occur between the end of World War II and 1956. Relocating firms from East Germany were larger/stronger than the average West German incumbent firm over the medium-term as measured by products produced. Immediately after their move, relocating firms produced on an average 1.4 products compared to incumbents' average of 1.7 products. This represented a decline from the pre-war capacity of these firms. Relocating firms, however, quickly expanded upon relocation and achieved an average of 2.2 products within 10 years and an average maximum size of 3.2 products.

Available historical data indicate that the greater medium-term strength of relocating firms was due primarily to more efficient production. Buenstorf and Guenther (2011) emphasize in particular the strong organizational performance of these firms after their relocation. On the other hand, we do not observe any evidence that relocating firms have a greater flexibility for switching across products (e.g. to meet changing demand). Likewise, the innovativeness of the firms appears similar. Richter and Streb (2011) do not identify material differences in pre-war innovativeness between East and West Germany.

Columns 7–9 describe the level of start-up entrants in these regions. In total, 1332 firms entered these regions in the post-war period to 2002. The average entrant has 1.3 product types. Approximately 54% of these entrants survived for 5 years or longer and 39% survived for 10 years. Many of these entrants (44%) entered during the same time period as the relocations, before 1956. Of these early entrants, 53 and 41% survived for 5 and 10 years, respectively.

Visually, the table suggests that relocations and entries have moderate spatial overlap at most. In absolute terms, Düsseldorf and Stuttgart are the top locations on both lists reflecting their greater shares of the industry as a whole. But there exists extensive variation otherwise. For example, Berlin had the third most entrants but only one relocating firm from the surrounding eastern Germany regions. The start-up overlay was closer to existing incumbent structures.[8] One way to quantify the spatial overlap is to normalize relocation and entrant counts by initial incumbent activity after the war. The spatial correlation of these normalized measures for relocations and entrants is just 0.2. This independence allows us to analyze these two phenomena jointly.

7 We identified 43 relocators in total. We require that relocators in our sample survive for 5 years after relocating. This restriction excludes a few marginal cases where it is not certain the extent to which the relocator resumed production. Two relocators from Silesia move to regions without incumbent firms (Oberland and Regensburg). These firms are effectively excluded from our sample as well. Finally, we drop three relocations within Berlin that are difficult to interpret.

8 Holmes and Stevens (2002), Glaeser and Kerr (2009), and Rosenthal and Strange (2010) discuss entrant spatial distributions and existing incumbents for the US.

4. Location decisions of relocating firms from the Soviet zone

We analyze the location choice problem of relocators from the Soviet zone to either the American or British zones with conditional logit models. We have 10 source regions in the Soviet occupation zone and 63 potential destination regions (40 with incumbents after World War II) in the American and British zones. For this analysis, we only consider relocations from eastern Germany as we do not have pre-war traits on conditions in Silesia/Prussia. The latter are, however, included in the survival analysis in Section 5.

Conditional logit estimations include fixed effects for relocating firms that account for traits of source regions. We develop three groups of explanatory variables for destination regions over which the location choice is made. First, we measure general traits of destination regions in 1950: population, population density, population change from 1939 to 1950, male share of population, (Schmitt et al., 1994), shortest distance to East German border, personal taxes collected from region, corporate taxes collected from region, self-employment share of population, wartime destruction measured through cubic meters of rubble per inhabitant and wartime destruction measured through the share of housing destroyed. The latter two measures are especially important given the convincing work of Burchardi and Hassan (2011) that wartime destruction shaped expellee placement, which we return to below. The taxation measures are our best proxies of local output.

Our second category includes measures of the machine tool industry for each region in 1949–1950: incumbent firm counts, entry rates, average number of products per incumbent, industry concentration ratio, pre-war patenting strength and the local distribution of production across several broad product categories.

Our third category of explanatory variables—and the key focus of our models—includes measures of the similarity of origin and destination regions. Thus, unlike measures like incumbent counts or population, these attributes are specific to origin–destination pairs. The first of these measures is geographic distance. Distance carries two potential effects in this context. First, greater distance likely raised the costs of relocations. On the other hand, greater distance might have been advantageous to the extent that firms relocated further away from the uncertainties that surrounded the border.

Our second measure is how similar the machine tool industries are in the origin and potential destination regions. This factor tests the extent to which industrial structures factored into decisions. Our measure is a count measure of product similarity across 36 different product types. We measure product types that were being produced in the origin region in eastern Germany before World War II in 1936. We do the same for potential destination regions in West Germany in 1949. Our measure sums product type matches between the two regions, which describes the similarity of conditions for entrants.[9]

Our third metric tests the role of non-economic factors and heuristics in these decisions. Following Falck et al. (2012), we measure cultural similarity between two regions as the similarity between the historical dialects spoken. Extensive research in

9 We find similar results when using 1936 traits for potential destination regions, but it is conceptually better to use conditions after the war. We purposefully do not compare the relocator's product portfolio when starting at the new location to the incumbent firms' product portfolios in the potential destination regions. The relocator's product portfolio might be endogenous to the location decision itself.

economics ties heightened social and economic interactions to ethnic, genetic and linguistic bonds.[10] In this study's context, dialect similarity partly represents familiarity with norms and conventions of the potential destination region. It may also reflect distant family ties (Hefele, 1998). With such uncertainty about economic conditions in potential destinations, these non-economic factors may have been especially important in decisions.

Linguist Georg Wenker conducted a unique survey of dialects between 1879 and 1888 at 45,000 schools across the German Empire. The resulting data, which contain almost 300 attributes of dialects by region, afford very fine grained comparisons of the dialect connections between locations. Falck et al. (2012) construct a dialect similarity matrix. This work further demonstrates that these dialect connections persist even to present in migration flows. We use their metrics for the cultural similarity of origin locations in eastern Germany and potential destinations in West Germany.

Figure 1 illustrates the location choice of the seven relocators from the region of Chemnitz-Ore Mountains in eastern Germany. The shading of the left map reflects the dialect similarity of the 63 regions in the American (solid outline) and British occupation zones with the Chemnitz region. Darker shading indicates higher dialect similarity. The shading of the right map reflects the product similarity between the Chemnitz region and potential destinations. Darker shading again indicates greater similarity.

The first observation is that distance is a factor in that the seven firms migrated farther into West Germany than random. Second, the chosen destination regions tended to have strong dialect similarity with Chemnitz—four of the seven cases fall into the highest two levels and none of the selected regions has below-average dialect similarity. Dialect similarity appears particularly relevant when selecting a region that is closer geographically. On the other hand, there is not a consistent pattern for product similarity, with a wide mixture of high and low similarities present.

Tables 2 and 3 extend this visual analysis to all relocations using conditional logit models (McFadden, 1973), finding that the Chemnitz patterns hold generally. To aid interpretation, we standardize our three similarity metrics to have zero mean and unit SD. Columns 1–3 of Table 2 enter our key pairwise measures in a univariate format, while Columns 4–6 include all three measures.

Geographic distance is the strongest factor in univariate and multivariate analyses, with relocators favoring more distant regions. This suggests that short-term transportation costs were less important than establishing new locations farther from the border. By itself, dialect/cultural similarity does not predict location choice. It is a strong factor, however, once also controlling for geographic distance. Similar to the Chemnitz example, there is a general negative correlation of −0.45 for geographic distance and dialect similarity, which partly explains their greater joint strength.

On the other hand, product similarity does not predict location choice. While the precision of the product similarity estimates are comparable to the other two metrics, the point estimates are much lower. Product similarity has −0.19 and −0.02 correlations with geographic distance and dialect similarity, respectively, and their joint estimation does not impact it much. This independence and persistent null effects

10 For example, Lazear (1999), Rauch and Trindade (2002), Kerr (2008), Spolaore and Wacziarg (2009), and Guiso et al. (2009). Falck et al. (2012) provide more extended references. See also the experimental results on status quo tendencies of Kahneman et al. (1991).

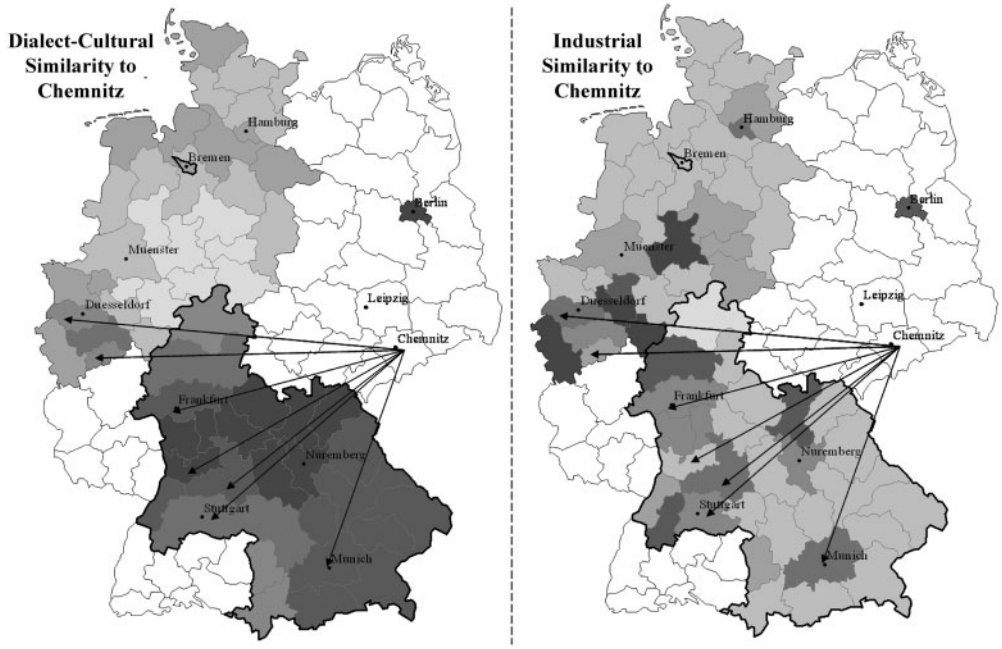

Figure 1. Relocation patterns to West Germany from Chemnitz region. *Notes*: Figure demonstrates the location choice of the seven relocators from the region of Chemnitz-Ore Mountains in eastern Germany. The shading of the left map reflects the dialect similarity of the 63 regions in the American (solid outline) and British occupation zones with the Chemnitz region. Darker shading indicates higher dialect similarity. The shading of the right map reflects the product similarity between the Chemnitz region and potential destinations. Darker shading again indicates greater similarity. Distance is a factor in that the seven firms migrated farther into West Germany than random. Second, the chosen destination regions tended to have strong dialect similarity with Chemnitz, while there is not a consistent pattern for product similarity.

(continued in Table 3) provide confidence that location choices were primarily made due to factors orthogonal to incumbent industrial structures.[11]

Columns 1–4 and 6 report robust SEs. Column 5 shows similar significance levels for our primary models when bootstrapping SEs. We likewise find similar results when clustering SEs by origin or destination region. The extended decomposition checks and fixed effects tests that we undertake next, however, reduce the sample size to a point where bootstrapped models may not converge correctly. We thus maintain simpler corrections that can be consistently applied.

We perform a number of robustness checks on these basic results. Column 6 of Table 2 shows that the results hold when excluding the three regions of Düsseldorf, Rhine-Main and Stuttgart that attract the most relocating firms. Thus, our results are not being driven solely by these regions and potential omitted traits or trends of them.

11 The base location choice model has 1759 observations. Crossing 63 regions with 28 relocators yields a total potential sample count of 1764. We have five cases of a firm in the eastern part of Berlin relocating and we do not allow for firms to relocate within Berlin by construction (we have dropped the three cases where this occurred; see Footnote 7). For these five cases, the choice set is restricted to 62 potential regions.

Table 2. Location choice for relocators from East Germany

	Geographic proximity estimation	Dialect proximity estimation	Industrial proximity estimation	Combined estimation	Column 4 with bootstrapped SEs	Column 4 excl. Düsseldorf, Rhine-Main and Stuttgart
	(1)	(2)	(3)	(4)	(5)	(6)
Geographic distance to destination region	0.429* (0.220)			0.942*** (0.293)	0.942*** (0.253)	0.968** (0.458)
Dialect similarity of destination region		0.257 (0.190)		0.828*** (0.284)	0.828*** (0.265)	1.276** (0.541)
Product similarity of destination region			−0.293 (0.252)	−0.317 (0.250)	−0.317 (0.343)	0.029 (0.273)
LR Chi-squared	3.99**	1.84	1.33	15.02***	17.13***	6.20*
Conditional group	Firm	Firm	Firm	Firm	Firm	Firm
Origin regions	10	10	10	10	10	10
Destination regions	63	63	63	63	63	60
Relocators	28	28	28	28	28	16
Observations	1759	1759	1759	1759	1759	958

Table reports conditional logit models for the location choice of West German regions by relocating firms from East Germany. Regressors measure the geographic distance, dialect similarity and industrial product similarity of the relocator's origin region in East Germany (pre-war) and the potential destination region in West Germany (post-war). All specifications condition on the relocating firm. The base location choice sample includes 28 relocating firms after relocators from Silesia are excluded due to data constraints on pre-war industrial conditions in Silesia. These excluded relocators are included in the hazard models of Tables 4–6. The relocation to Berlin is excluded from this sample due to lack of neighboring regions outside of the Soviet zone. Regressions are unweighted. Columns 1–4 and 6 report robust SEs and Column 5 reports bootstrapped SEs. Column 6 excludes the three regions that received the largest inflows of relocating firms. ***, **, * denote statistical significance at the 1, 5 and 10% levels, respectively.

Table 3. Location choice for relocators from east Germany, additional robustness tests

	Baseline location choice model with destination covariates	Baseline location choice model with destination fixed effects	Sample restricted to relocators that survive 10 years in new region	Region choice set restricted to destinations with			
				Similar population density to true choice	Similar population levels to true choice	Similar industry concentration in machine tools to true choice	A common geographic border to true choice
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Geographic distance to destination region	1.531** (0.688)	2.141*** (0.932)	0.921*** (0.314)	0.532* (0.283)	0.735** (0.297)	0.676*** (0.230)	–
Dialect similarity of destination region	0.978** (0.431)	1.229*** (0.545)	0.972*** (0.313)	0.515** (0.249)	0.732*** (0.281)	0.476** (0.202)	–
Product similarity of destination region	−0.237 (0.246)	−0.183 (0.229)	−0.277 (0.292)	−0.271 (0.235)	−0.086 (0.224)	−0.048 (0.154)	−0.431 (0.270)
LR Chi-squared	94.67***	112.25***	13.93***	7.92**	10.75**	10.56**	2.56
Conditional group	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Origin regions	10	10	9	10	10	10	10
Destination regions	63	63	63	43	43	41	44
Relocators	28	28	24	28	28	28	27
Observations	1759	1759	1507	308	308	292	154

See Table 2. Column 1 includes destination region covariates listed in the text. Of the 18 traits, only population levels and population density are statistically important for explaining location choice. Column 2 includes destination region fixed effects. The fixed effects are jointly insignificant with a Chi-squared value of 5.21. Column 3 restricts the sample to the 24 relocators that survived at least 10 years at their new location. Column 4 restricts the set of potential destination regions to the actual destination region plus 10 counterfactuals most similar in terms of population density. Column 5 restricts the set of potential destination regions to the actual destination region plus 10 counterfactuals most similar in terms of population levels. Column 6 restricts the set of potential destination regions to the actual destination region plus 10 counterfactuals most similar in terms of industrial concentration. Column 7 restricts the set of potential destination regions to the actual destination region plus regions that border it.

Column 1 of Table 3 continues by including the regional covariates listed earlier. To conserve space, we only report the coefficient values for our key measures (full results are available upon request). Among the 18 covariates we include, only population and population density are statistically significant for explaining entry. The link to population is natural as it is our main metric of the size of each region, while population density is only marginally statistically significant. None of the other general covariates are important and none of the covariates related to the machine tool industry itself are important. The inclusion of these controls does not impact our pairwise similarity metrics and their lack of explanatory power speaks to limited location choice planning.

Column 2 takes an alternative approach of including fixed effects for potential destination regions. These effects capture traits of destination regions that are common to relocators from all source regions. In addition to Column 1's covariates that we can measure, these fixed effects also capture many unobserved characteristics or expectations of regions that existed in the uncertain environment after World War II. The results are again comparable and suggest a limited role for industrial similarity. Moreover, the fixed effects are jointly insignificant with a Chi-squared value of 5.21, further highlighting the limited role of local conditions in location decisions.

Column 3 finds similar results when restricting the sample to relocators that survived at least 10 years in West Germany. In general, it does not appear that relocation choices were motivated differently among relocators with short versus long subsequent life spans.

Columns 4–7 report tests of the independence of irrelevant alternatives assumption by restricting the set of potential destinations. Column 4 restricts counterfactual regions to those with similar levels of population density as the chosen region, Column 5 restricts counterfactual regions to those with similar population levels and Column 6 restricts counterfactual regions to those with similar levels of industrial concentration (measured as a Herfindahl index across 24 industries for machine tools using 1925 data). The greater importance for distance and dialect/cultural similarity persists in these refined choice sets.

Finally, Column 7 alternatively restricts counterfactual regions to just those that bordered the actual destination region. This restriction removes the distance and dialect variation, but it allows us to test very narrowly the product similarity index. Relocators continue to select regions with very limited attention to incumbent industrial structures even among regions that neighbor their true choice.

To summarize, both the case studies and empirical models indicate that existing incumbent structures across regions were not a major factor in the location choices of firms fleeing East Germany. Instead, non-economic factors like greater distance and dialect similarity dominated selection. This provides confidence that these relocations provided arguably exogenous shocks to the local machine tool industries. We next turn to the impact of these shocks on the performance of incumbent firms.

5. The effect of relocators on incumbent survival

5.1. Empirical strategy

We estimate the effect of relocated firms from the Soviet zone on incumbent survival in the affected West German regions. These firms were quite different from start-ups as they brought with them (to varying degrees) industry experience and technical

knowledge, networks of domestic and foreign customers, portfolios of existing products and similar assets that could be built upon in their new locations. Indeed, these relocated firms recovered quickly and developed to be as successful as local incumbents. This group has been taken as evidence for persistent organizational capabilities of firms that are independent of a single spatial location (Buenstorf and Guenther, 2011).

The large magnitudes of these random shocks, along with the localized variations in resource constraints for workers that are discussed below, provide a fruitful laboratory for comparing beneficial agglomeration economies versus adverse competition for localized inputs.[12] Importantly, our empirical setting is also free of variations in local demand to a first approximation. As discussed in greater detail earlier, machine tools are an intermediate input to other firms, and domestic and international trade is central to the machine tool industry and its wide product markets (Carlsson, 1989).

We begin our survival estimations with 1949. This is several years after the 1945 German surrender, but it took some time for the industry to reorganize. War crime prosecutions lasted until 1949 and industrial production was controlled by occupational forces during the interim. Heavy machine tool production was entirely prohibited immediately after the war and other fields were severely restricted. Machine tool production in West Germany began to recover in 1949 with the Petersberg Agreement, which set the framework for West German sovereignty and a new market-based economy (Schwab, 1996). The year 1949 also marked a clear recognition that the future paths of East and West Germany would differ substantially, which began the rush to relocate.

Figures 2 and 3 present descriptive evidence on the differences between relocating firms and new entrants. Figure 2 divides West German regions into three groups: those regions that experienced no relocations, those that experienced moderate rates and those that experienced high rates. Rates of relocation are determined by the number of relocators relative to the incumbent stock and the high group includes those regions with ratios higher than the mean ratio for regions that experienced at least one relocation.

Within a few years of the final relocation, a persistent difference in failure rates opens between incumbents in regions that experienced relocations and those that did not. This difference only closes itself after a period of 40 years. Moreover, looking within regions that experienced relocation, the failure rates are consistently higher for incumbents that are in regions that experienced high rates of relocations relative to incumbents located in regions that experienced moderate rates. Figure 2 also shows changes in failure patterns that commence in the late 1970s that we further analyze below.

Figure 3, on the other hand, shows a very different pattern with new entrants. To match our relocation sample as closely as possible, we consider entrants during the period of the relocations that also survived 5 years. As every region with incumbents has new entrants during the relocation period, we divide the sample into three equal-sized groups based upon the rates of entry relative to the incumbent stock. Failure rates are in the opposite pattern from Figure 2. Incumbents in regions with the highest entry rates have the lowest failure rates, while incumbents in regions with the lowest entry rates have the highest failure rates. As the introduction noted, new entrants

12 The appendix provides a simple representation of firm optimization under the conditions identified for the machine tool industry.

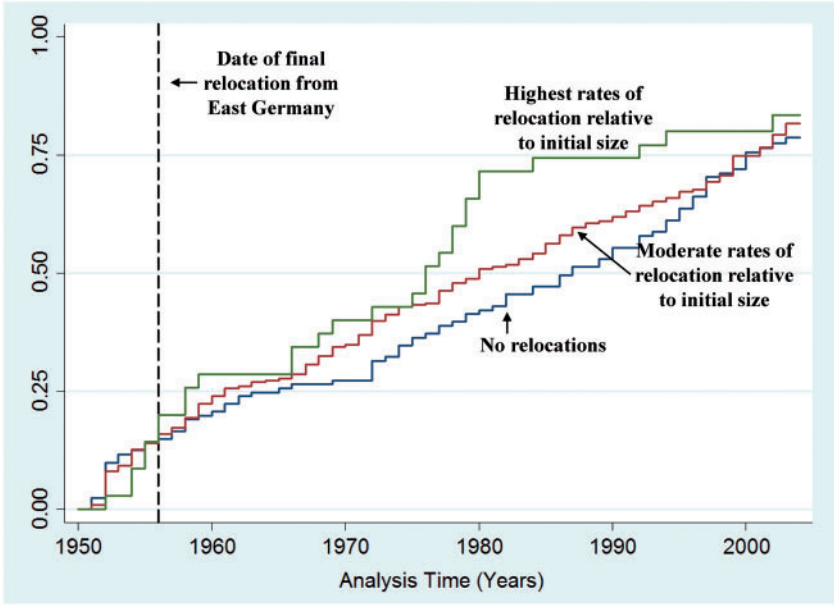

Figure 2. Failure estimates of incumbents by degree of relocation. *Notes*: Figure documents the Kaplan–Meier failure rates for incumbent machine tool firms. Regions are grouped into three bins: those with high rates of relocating firms from eastern Germany to the region, those with moderate rates of relocating firms and those with no relocating firms. Rates of relocation are determined by the number of relocating firms divided by the incumbent machine tool firms in the region. High rates are those regions above the mean ratio for regions that experience a relocation. The first 6 years of analysis time is the period in which the relocations occur. High rates of relocating firms are associated with greater failure rates for incumbent firms.

made their entry decisions and location choices much more opportunistically than relocating firms, for example responding to short-term spatial disequilibria with favorable benefit/cost ratios.

To quantify how relocators and entrants affected incumbent survival, we analyze a proportional Cox (1972) hazard model with time-varying covariates:

$$h_i(t|\cdot) = h_0(t) \cdot \exp(\alpha_r + \alpha_t + \beta_0 RZ_{rt} + \beta_1 RE_{rt} + \gamma X_i + \varepsilon_{it}),$$

where $h_i(t|\cdot)$ is the hazard rate or risk of failure of incumbent firm i located in region r at time t conditional on a set of regressors. $h_0(t)$ is the unspecified baseline hazard function. We take into consideration the fact that incumbent firms have been at risk of failure since their founding, even though we do not analyze their survival before 1949.[13] Some of the incumbent firms are still active today. We relate these hazard functions to relocations and start-up entry in the incumbents' planning regions.

13 We lack founding years for some incumbents. We therefore use the year of first appearance in the survey (between 1936 and 1949) as the time at which a firm becomes at risk of failure. Our results are robust across various modeling strategies with respect to this timing.

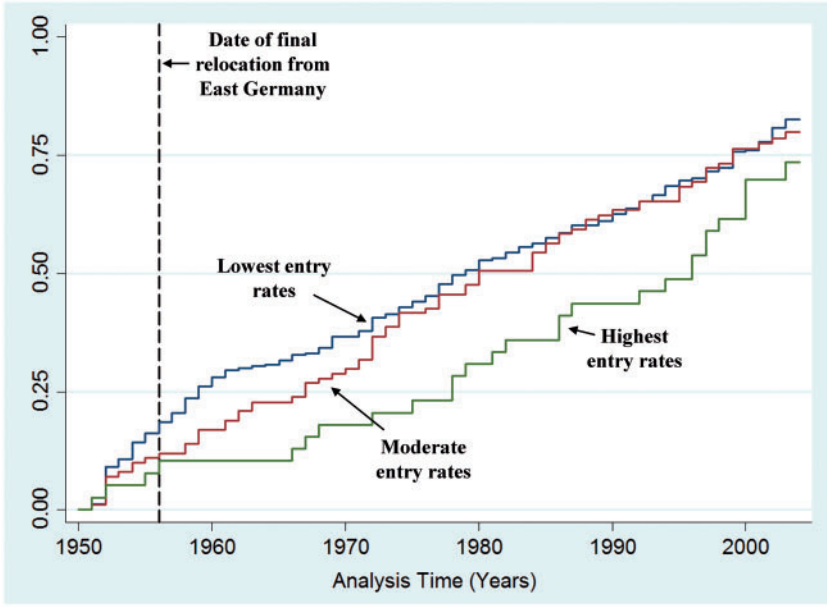

Figure 3. Failure estimates of incumbents by degree of entry. *Notes*: Figure documents the Kaplan–Meier failure rates for incumbent machine tool firms. Regions are grouped into three bins: those with high rates of entry over 1949–1955, those with moderate rates of entry and those with low rates of entry. Rates of entry are determined by the number of entrants that survive for 5 years divided by the incumbent machine tool firms in the region. The first 6 years of analysis time represents the period in which these entry rates are measured, equivalent to relocations documented in Figure 2. While high rates of relocating firms are associated with greater failure rates, the opposite is true for new entrants.

RZ_{rt} is a count variable of relocations to a region. In our first specification, we treat each relocator with the same weight, such that RZ_{rt} is the cumulative count of relocating firms to region r by time t. In our second approach, we weight the importance of relocators by their size at entry, which is proxied by initial product type counts upon relocation. The coefficient of interest is β_0 or $\exp(\beta_0)$. The latter is the proportional change in the incumbent firm's hazard rate resulting from the relocation of a firm from the Soviet zone to region r. RE_{rt} is a symmetrical treatment for entering start-up firms.

We include time fixed effects α_t to capture aggregate changes in hazard rates common to regions. These are due, for example, to German business cycles or industry trends for machine tools. The region fixed effects α_r control for regional variation in the baseline hazard rate due to factors like fixed agglomeration externalities, natural advantages, the degree of wartime destruction in a region or local policies. Given the region-specific baseline hazard rates, $\exp(\beta_0)$ gives us the proportional increase in the incumbent firm's hazard rate after the arrival of a relocator.

Finally, we include two firm-specific covariates. The first of these is the number of product types an incumbent firm supplied in 1949, where we consider a firm's product variety as a good proxy for firm size (Franco and Filson, 2006; Klepper and Thompson, 2006; Coad and Guenther, 2012). Larger initial firm size and product variety reduced

the likelihood of firm failure. The second trait is the incumbent's major product class in 1949, as technology areas and industries differed in the expected longevity of businesses (Sciberras and Payne, 1985).

5.2. Basic survival results

Tables 4 and 5 report the basic hazard estimations. We report proportional changes for the hazard ratio, $\exp(\beta)$. Coefficients >1 signify an increased risk of failure, while values <1 signify decreased risk. We cluster SEs by region and statistical significance is measured relative to $\exp(\beta) = 1$.

Table 4 uses the firm count approach and finds that relocating firms substantially raised the hazard rate of failure for local incumbents—one additional relocation was associated with a 25% higher likelihood of firm failure compared to the baseline. This effect for relocating firms contrasts sharply with the coefficient for start-up entrants. Start-up entrants were associated with a very small decline in incumbent hazard rates. The linear differences between the relocation and entry effects are statistically significant.

Columns 2–6 refine this assessment by contrasting the relocation response with different sets of start-up entrants. First, many start-ups are short-lived, with 45% of entrants to the machine tool industry failing before 5 years. Columns 2 and 3 restrict entrants to those that survived at least 5 or 10 years, respectively. These entrants were perhaps more comparable in quality to the relocated firms, at least over a medium horizon, but the difference persists. Columns 4–6 repeat these specifications restricting start-up entrants to the period before 1956. With this restriction, the window for new entrants matches the period in which the relocations occurred. The results are similar, suggesting that the effective time periods across types are not driving our results.

While proportional effects are most accurately estimated, some simple calculations can provide additional perspective. First, Table 4 suggests relocating firms increased hazard rates for incumbents by 20–25%. The average region in our sample experienced 0.78 relocations (SD of 1.5) on a baseline of 9.85 incumbents. Thus, a back-of-the-envelope calculation suggests a decline of about 1.5–1.9 incumbents for the typical region. This displacement is greater than the relocating firm count, but it does not necessarily represent a decline in overall production as relocating firms grew on an average to be almost twice the size of the average Western incumbent and smaller incumbents were more likely to fail. If anything, these two effects seem to more-or-less balance out.

Second, Table 1 shows that there were many more entrants than relocators. A crude calculation that applies the marginal effects to the total numbers of each type during 1949–2002 suggests that these aggregate effects of relocators and entrants are comparable in economic magnitude. This comparability is remarkable given the very short window in which these relocations occurred. Restricting to entrants during the period before 1956, the magnitude of the relocation effects are about twice that of new entrants. Buenstorf and Guenther (2011) demonstrate that relocated firms recovered quickly and became as successful as local incumbents, so these firms are clearly distinct from typical entrants.

Table 5 repeats these specifications using initial product type counts to weight the importance of relocators and entrants. The pattern of results is very similar to Table 4, with the more refined variation yielding more precisely estimated effects. The average relocator had 1.42 product types at entry. This mean entrant would yield

Table 4. Incumbent hazard models with firm counts

	Baseline hazard model of incumbent failure	Restricting entrant counts to firms surviving for 5 years	Restricting entrant counts to firms surviving for 10 years	Restricting to entrants before 1956		
				Baseline hazard model of incumbent failure	Restricting entrant counts to firms surviving for 5 years	Restricting entrant counts to firms surviving for 10 years
	(1)	(2)	(3)	(4)	(5)	(6)
Firm count of relocators to incumbent's region	1.248* (0.132)	1.314* (0.163)	1.352* (0.208)	1.172* (0.100)	1.185* (0.114)	1.190* (0.117)
Firm count of new entrants in incumbent's region	0.993** (0.003)	0.982** (0.007)	0.971*** (0.011)	0.993 (0.007)	0.986 (0.013)	0.982 (0.016)
Incumbent's product count in 1949	0.824*** (0.065)	0.824*** (0.065)	0.823*** (0.065)	0.827*** (0.064)	0.827** (0.064)	0.827** (0.064)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Product class fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Subjects	394	394	394	394	394	394
Failures	316	316	316	316	316	316
Observations	12,041	12,041	12,041	12,041	12,041	12,041

Table reports Cox hazard models for incumbent failure/death in West German regions. Explanatory factors for incumbent failure are relocating firms from East Germany and new start-up entrants. Relocating firms consistently increase incumbent hazard of failure, while start-up entrants do not. Estimations control for incumbent product counts in 1949 (i.e. firm size) and fixed effects for region, product class and time period. Reported coefficients are relative to a value of one, with coefficients >1 signifying increased hazard of firm failure. Estimations quantify the strengths of relocations and entrants with simple firm counts. The first column considers all entrants. The second and third columns restrict entrants to high-quality firms that survive 5 and 10 years, respectively. The fourth through sixth columns consider entry before 1956, which is the date of the last relocation from East Germany. The sample includes incumbent firms from 40 West German regions. After World War II, 31 relocating firms moved from East Germany to 15 of these regions. Estimations are unweighted and cluster SEs by planning region. Wald tests for all estimations are significant at the 1% level. ***, **, * denote statistical significance at the 1, 5 and 10% levels, respectively.

Table 5. Incumbent hazard models with firm product counts

	Baseline hazard model of incumbent failure	Restricting entrant counts to firms surviving for 5 years	Restricting entrant counts to firms surviving for 10 years	Restricting to entrants before 1956		
				Baseline hazard model of incumbent failure	Restricting entrant counts to firms surviving for 5 years	Restricting entrant counts to firms surviving for 10 years
	(1)	(2)	(3)	(4)	(5)	(6)
Product count of relocators to incumbent's region	1.155** (0.066)	1.189*** (0.068)	1.215*** (0.074)	1.152** (0.070)	1.182** (0.097)	1.192** (0.102)
Product count of new entrants in incumbent's region	0.993** (0.003)	0.984*** (0.005)	0.974* (0.016)	0.987* (0.008)	0.975 (0.016)	0.968 (0.020)
Incumbent's product count in 1949	0.824*** (0.065)	0.823*** (0.066)	0.823*** (0.066)	0.827*** (0.064)	0.827** (0.064)	0.827** (0.064)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Product class fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Subjects	394	394	394	394	394	394
Failures	316	316	316	316	316	316
Observations	12,041	12,041	12,041	12,041	12,041	12,041

See Table 4. Estimations quantify the strengths of relocations and entrants with the product counts of firms. These product counts are the best available measure of firm size. Relocating firms consistently increase incumbent hazard of failure, while start-up entrants do not.

a 22% increase in incumbent failure, which is slightly less than the mean effect of 25% in Table 4.[14]

These results are robust to a variety of further specification variants. For example, we find similar patterns when including pre-trends for regions or interactions of product class and year fixed effects. We find comparable outcomes when testing simpler indicator variables for pre–post relocations to a region. Many relocating firms go to three regions of Düsseldorf, Rhine-Main and Stuttgart. We find very similar results when including interactions of year effects and indicator variables for being in these three regions. Across multiple techniques, the higher incumbent failure rate following relocations emerges with a generally consistent economic magnitude.

Figures 2 and 3 show visible changes after the mid-1970s in survival conditions due to many adjustments occurring in the machine tool industry, ranging from exchange rate adjustments to the introduction of computer-based technologies.[15] German reunification and the collapse of the Soviet Union are major events toward the end of our sample period and the industry faced strong Asian competition in the 1990s. While important, these events and periods do not overly influence our results. The hazard ratio in our baseline model from Column 1 of Table 4 is 1.203 (0.122) when stopping the analysis in 1970; it is 1.197 (0.091) when stopping the analysis in 1990. Thus, relocating firms influenced incumbent survival both in the short-run, during a period of full German employment and international rebuilding, and over the long-run as firm adjustments and competitiveness became more critical for survival.

These survival estimations focus on the extensive margin of incumbent performance. We also undertook unreported specifications of product type counts of incumbents to model the intensive margin for surviving incumbents. The historical nature of our data limits us from calculating detailed productivity measures, but product type counts and survival are often closely linked to productivity (Griliches and Regev, 1995). Effects on the intensive margin were much smaller and generally sensitive to specification choice. One exception was (not surprisingly) a strong, sharp decline in product types for failing incumbents immediately before exit. A second result pointed to increased product variants for surviving incumbents following relocations. Nevertheless, our general conclusions from this extended analysis are that extensive margin effects for incumbent survival were much more important than intensive margin differences for surviving firms.

5.3. Exploring the source of input competition in the local labor market

As a final step, we investigate more closely the input competition mechanism. The German labor force was devastated by the war and a very important factor in rebuilding this labor force was the distribution of expellees. Expellees were German

14 This differential suggests that larger relocations may have had disproportionate effects, but that non-linearities in treatment would be second order in importance. Along these lines, unreported specifications find evidence that relocations of larger firms had additional effects for incumbent failure, but these differences are not statistically significant. This may in part descend from the fact that many relocators with small initial product type counts were able to restore production capacity quickly upon arrival.

15 The changes are discussed in Marx (1979), Carlsson (1989), Glunk (1991), Wieandt (1994), Schwab (1996), Fleischer (1997), Ifo (1997), Hirsch-Kreinsen (2000), Arnold (2003), Roy (2003), Roy and McEvily (2004), Verein Deutscher Werkzeugmaschinenfabriken e.V. (2005), and Conrad (2006). Guenther (2009) provides an extended review.

citizens or ethnic Germans who lived within the eastern German borders as they existed 1917–1937 or in Austria–Hungary before or during the war (§1, Federal Expellee Law, 19 May 1953). Late in World War II, these individuals were forced by the Soviet Red Army to leave their homelands and settle within the new borders of Germany or Austria. This expulsion was furthered by the Potsdam Treaty. Almost 12 million ethnic Germans fled or were expelled from their homes in East Prussia, Pomerania, Silesia, East Brandenburg and the Sudetenland to find refuge in other German states. A total of 8 million expellees came to West Germany while 4 million settled in East Germany.

Expellees had little choice in where they were settled, being generally distributed across regions based on the availability of food and housing by the authorities. These often tended to be more rural locations or areas with less wartime destruction. Burchardi and Hassan (2011) examine these expellees and their social ties after German reunification. Important for our study, Burchardi and Hassan (2011) demonstrate that these expellees were placed across German regions systemically by factors that we found earlier to be of limited importance for explaining machine tool relocation. The only overlap is potentially in population density, which we further test below.

At first, it was difficult for the expellees to work. For example, their formal qualifications were frequently not recognized as valid. However, West Germany enacted the Federal Expellee Law (*Bundesvertriebenengesetz*) in 1953 that regulated the expellees' status and granted them full access to the local labor market. This exogenous push provides important variation in local workforce conditions. Competition for employees was weaker in planning regions with a higher influx of expellees. Moreover, the differences across regions were quite substantial. The last column in Table 1 shows the variation in expellee shares. Data are available in eight bins from the *Bundesminister für Heimatvertriebene* (1952). Out of 40 planning regions in our incumbent sample, 8 had an expellee influx of <10%, while five zones had an influx >30%.

We group regions into three bins based upon these expellee shares. Low shares are (0%, 10%), medium shares are (10%, 20%) and high shares are those >20%. These three groups are of equal size with respect to the number of relocations. Moreover, each of these bins contains one of the three largest destinations for relocations. Düsseldorf is among the lowest shares, Rhine-Main is in the middle bin and Stuttgart is among the highest shares. This extensive variation is a fortunate byproduct of the different circumstances driving on the one hand the spatial distributions of machine tool relocations and, on the other hand, of expellees. The spatial correlation of the expellee shares and the machine tool relocations is −0.19.[16]

Table 6 shows that the impact of relocating firms on incumbent survival was particularly strong in regions with lower labor influx due to expellees. Columns 1–3 use firm counts to model firm inflows similar to Table 4, while Columns 4–6 use the product type counts method of Table 5. The first and fourth columns demonstrate this pattern

16 The labor shortages the 1950s and 1960s were extreme. Their severity led Germany to negotiate guest worker agreements from 1955 on with Italy, Spain, Greece, Turkey, Morocco, Portugal, Tunisia and Yugoslavia. Until the end of these agreements in 1973, nearly 3 million guest workers came to West Germany. These guest workers mostly worked as unskilled workers in manufacturing, similar to expellees. The post-war census shows that the spatial correlation of the share of guest workers and expellees is significantly negative. This is evidence that regions that experienced a relatively large inflow of expellees were—at least in the 1950s and early 1960s—less constrained in their economic development since they had a large pool of labor to draw from.

Table 6. Incumbent hazard models with labor force differentials as resource constraints

	Hazard models using raw firm counts to measure strength of relocations and entry (Table 4)			Hazard models using product capacity to measure strength of relocations and entry (Table 5)		
	Full sample using all entrants (1)	Moderate population density using all entrants (2)	Moderate density and entrants before 1956 (3)	Full sample using all entrants (4)	Moderate population density using all entrants (5)	Moderate density and entrants before 1956 (6)
Strength of relocators to incumbent's region as indicated by column header						
×weak expellee growth for region workforce	1.483* (0.269)	–	–	1.170* (0.104)	–	–
×moderate expellee growth for region workforce	1.059*** (0.022)	1.076** (0.037)	1.048* (0.029)	1.062*** (0.015)	1.079*** (0.026)	1.064*** (0.021)
×high expellee growth for region workforce	0.917 (0.082)	1.004 (0.121)	0.845 (0.119)	0.961 (0.045)	1.027 (0.072)	0.947 (0.071)
Strength of new entrants in incumbent's region	0.991** (0.004)	0.985* (0.008)	1.001 (0.031)	0.993** (0.003)	0.988** (0.006)	0.994 (0.019)
Incumbent's product count in 1949	0.824*** (0.065)	0.741*** (0.075)	0.745*** (0.078)	0.824*** (0.065)	0.741*** (0.075)	0.746*** (0.078)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Product class fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Subjects	394	180	180	394	180	180
Failures	316	134	134	316	134	134
Observations	12,041	5757	5757	12,041	5757	5757

See Tables 4 and 5. Estimations quantify the importance of labor resource constraints on how the relocating firms impact incumbent survival. The strength of relocations is interacted with indicator variables for low, medium and high expellee growth of workforce after the war. These expellees exogenously increased the size of the local workforce. Low shares are (0%, 10%), medium shares are (10%, 20%) and high shares are those >20%. Effects are estimated independently for each group (i.e. there is no excluded group). The first three columns measure the strength of relocations and entry using firm counts similar to Table 4. The second three columns measure strength of relocations and entry using product counts of firms similar to Table 5. Within each triplet, the second column restricts the sample to regions with moderate population densities and the third column further restricts to entrants before 1956. Relocating firms consistently increase incumbent hazard of failure in regions where labor supplies are constrained, but not in regions also experiencing a sharp increase in workforce growth. Estimations are unweighted and cluster SEs by planning region. Wald tests for all estimations are significant at the 1% level. ***, **, * denote statistical significance at the 1, 5 and 10% levels, respectively.

for the full sample. Regions with low labor influx experienced the fiercest competition for labor and the effect of relocations on incumbent survival was twice the sample average. The increase in the incumbents' risk of failure is somewhat smaller in the intermediate group of regions. Most important, there was no increase in failure among regions with the largest expellee influx. Table 6's estimations jointly measure these effects and we find similar results when separately considering each group of expellee shares.

Columns 2 and 5 also show these results hold when restricting the sample to regions with moderate population density. We undertake this robustness check due to the tilt toward rural areas in expellee distributions. Expellees often ended up in rural parts because cities were most affected by the bombings. Restricting the sample to more rural areas thus checks whether wartime destruction might be a confounding factor that influenced both the inflow of expellees and the survival perspectives of incumbents. There are insufficient observations among regions with moderate population densities to estimate the low expellee effect, but we are able to compare the middle and high expellee regions. This is effectively a matching exercise among areas of comparable population density and the estimations show that the risk of failure was larger in the regions that experienced less of an expellee labor inflow. Columns 3 and 6 also show comparable results when using entrant counts before 1956. These estimations suggest that resource constraints were particularly important in how relocations impacted incumbents.

6. Conclusions

The relocation of the machine tool industry from the Soviet zone of post-war Germany to western regions is a unique setting for studying the impact of industrial structures on incumbent survival. The location decisions by migrating owners—driven mostly by non-economic factors and undertaken hastily due to extreme duress—offers an exogenous shock to local industries that is rare in economic geography. We find that relocations increased a local incumbent's risk of failure by ~25%. These effects were particularly acute in locations with constrained labor resources; they also differ substantially from more opportunistic entrants.

Our review of the evidence leads us to the tentative conclusion that welfare likely did not decline as a result of the migration, at least in the medium run and longer. The relocating firms were quite strong and experienced substantial growth in their new home regions; many of these firms are still in operation today. To the limited extent that we can differentiate across incumbents using measures like product counts, the displacement also appears to have occurred among smaller/weaker incumbents. Throughout this period, the industry experienced growth and strong employment and our data suggest that relocating firms would have had the size to absorb employment from displaced firms. Thus, the reallocation of resources and selection effects would likely have not reduced welfare in the medium run and longer. Unfortunately, the historical record and data granularity are insufficient for making stronger statements about ultimate welfare gains versus balanced net effects. Likewise, we are unable to undertake assessments of the short-run transition that may have included localized worker displacement that would have been costly.

Though based on an historical time episode and one specific industry, our results show that heightened firm density can raise costs for incumbent firms in addition to the

often-cited agglomeration benefits. This is an important consideration, for example, when policy makers contemplate efforts to attract large firms to their local areas versus other alternatives (Falck et al., 2010; Duranton, 2011).

Funding

This research was funded by Harvard Business School.

Acknowledgements

We thank Gilles Duranton, Steve Gibbons, Bob Hart, Wen-Chi Liao, Volker Nitsch, Henry Overman, Marcello Pagnini, Ralf Richter, William Strange, Jochen Streb, Matthew Turner, anonymous referees and seminar participants at the Council for Regional Economics, Cambridge University, European Economic Association, European Economic Association, European Regional Science Association, German Economic Association, North American Summer Meeting of the Econometric Society, Royal Economic Society, University of Aalborg, University of Essex, University of Munich, National University of Singapore, University of St. Andrews, University of Stirling, University of Toronto, University of Utrecht and Urban Economic Association for insightful comments and suggestions. Parts of this article were written while Falck was visiting Harvard University, Heblich was visiting the University of Toronto and Kerr was visiting the Bank of Finland. They acknowledge the hospitality of these institutions.

References

Acemoglu, D., Akcigit, U., Bloom, N., Kerr, W. (2012) Innovation, reallocation, and growth. Working Paper.

Arnold, H. M. (2003) *Technology Shocks*. Heidelberg: Physica.

Arzaghi, M., Henderson, V. (2008) Networking off madison avenue. *Review of Economic Studies*, 75: 1011–1038.

Ashburn, A. (1988) The machine tool industry: the crumbling foundation. In D. A. Hicks (ed.) *Is New Technology Enough? Making and Remaking of U.S. Basic Industry*. Washington, DC: American Enterprise Institute for Public Policy Research.

Behrens, K., Duranton, G., Robert-Nicoud, F. (2010) Productive cities: agglomeration, selection and sorting. Working Paper.

Boschma, R., Frenken, K. (2011) The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, 11: 295–307.

Buenstorf, G., Guenther, C. (2011) No place like home? Relocation, capabilities, and firm survival in the German machine tool industry after World War II. *Industrial and Corporate Change*, 20: 1–28.

Bundesminister für Heimatvertriebene (1952) Heimatvertriebene Bevölkerung in Stadt- u. Landkreisen: Bonn.

Burchardi, K., Hassan, T. (2011) The economic impact of social ties: evidence from german reunification. Working Paper.

Carlsson, B. (1989) Small-scale industry at a crossroad: U.S. machine tools in global perspective. *Small Business Economics*, 1: 245–261.

Coad, A., Guenther, C. (2012) Diversification patterns and survival as firms mature. *Small Business Economics*, forthcoming. doi:10.1007/s11187-012-9447-7.

Combes, P.-P., Duranton, G., Gibillon, L. (2010) The costs of agglomeration: land prices in French cities. Working Paper.

Combes, P.-P., Duranton, G., Gibillon, L. (2011) Identification of agglomeration economies. *Journal of Economic Geography*, 11: 253–266.

Conrad, K. (2006) Steuerungstechnik. In K.-J. Conrad (ed.) *Taschenbuch der Werkzeugmaschinen*. München/Wien: Carl Hanser Verlag.

Cox, D. R. (1972) Regression models and life tables (with discussion). *Journal of the Royal Statistical Society, Series B*, 34: 187–220.
Dauth, W. (2011) The mysteries of the trade: interindustry spillovers in cities. Working Paper.
Delgado, M., Porter, M., Stern, S. (2010a) Clusters, convergence and economic performance. Working Paper.
Delgado, M., Porter, M., Stern, S. (2010b) Clusters and entrepreneurship. *Journal of Economic Geography*, 10: 495–518.
Desrochers, P., Leppala, S. (2011) Opening up the 'Jacobs Spillovers' black box: local diversity, creativity and the processes underlying new combinations. *Journal of Economic Geography*, 11: 843–863.
Diamond, C., Simon, C. (1990) Industrial specialization and the returns to labor. *Journal of Labor Economics*, 8: 175–201.
Drennan, M., Kelley, H. (2011) Measuring urban agglomeration economies with office rents. *Journal of Economic Geography*, 11: 481–507.
Duranton, G. (2011) California dreamin': the feeble case for cluster policies. *Review of Economic Analysis*, 3: 3–45.
Duranton, G., Overman, H. (2005) Testing for localization using micro-geographic data. *Review of Economic Studies*, 72: 1077–1106.
Duranton, G., Puga, D. (2004) Micro-foundations of urban agglomeration economies. In V. Henderson, J.-F. Thisse (eds) *Handbook of Regional and Urban Economics*, vol. 4, pp. 2063–2117. Amsterdam: North-Holland.
Ellison, G., Glaeser, E., Kerr, W. (2010) What causes industry agglomeration? Evidence from coagglomeration patterns. *American Economic Review*, 100: 1195–1213.
Falck, O., Heblich, S., Kipar, S. (2010) Industrial innovation: direct evidence from a cluster-oriented policy. *Regional Science and Urban Economics*, 40: 574–582.
Falck, O., Heblich, S., Lameli, A., Südekum, J. (2012) Dialects, cultural identity, and economic exchange. *Journal of Urban Economics*, 72: 225–239.
Fallick, B., Fleischman, C., Rebitzer, J. (2006) Job-hopping in Silicon Valley: some evidence concerning the microfoundations of a high-technology cluster. *Review of Economics and Statistics*, 88: 472–481.
Figueiredo, O., Guimaraes, P., Woodward, D. (2009) Localization economies and establishment size: Was Marshall right after all? *Journal of Economic Geography*, 9: 853–868.
Fleischer, M. (1997) *The Inefficiency Trap: Strategy Failure in the German Machine Tool Industry*. Berlin: Ed. Sigma.
Franco, A. M., Filson, D. (2006) Knowledge diffusion through employee mobility. *RAND Journal of Economics*, 37: 841–860.
Fu, S., Ross, S. (2010) Wage premia in employment clusters: does worker sorting bias estimates? Working Paper.
Gardiner, B., Martin, R., Tyler, P. (2011) Does spatial agglomeration increase national growth: some evidence from Europe. *Journal of Economic Geography*, 11: 979–1006.
Glaeser, E. (2008) *Cities, Agglomeration and Spatial Equilibrium*. Oxford: Oxford University Press.
Glaeser, E., Kerr, W. (2009) Local industrial conditions and entrepreneurship: how much of the spatial distribution can we explain? *Journal of Economics and Management Strategy*, 18: 623–663.
Glaeser, E., Kerr, W., Ponzetto, G. (2010) Clusters of entrepreneurship. *Journal of Urban Economics*, 67: 150–168.
Glunk, F. R. (1991) *Ein Jahrhundert VDW*. München: Britting Verlag.
Greenstone, M., Hornbeck, R., Moretti, E. (2010) Identifying agglomeration spillovers: evidence from winners and losers of large plant openings. *Journal of Political Economy*, 118: 536–598.
Griliches, Z., Regev, H. (1995) Firm productivity in Israeli industry 1979–1988. *Journal of Econometrics*, 65: 175–203.
Guenther, C. (2009) Structural change in the German machine tool market - An empirical investigation of technological, regional, and firm-specific developments. Dissertation, Friedrich-Schiller-Universität, Jena.

Guiso, L., Sapienza, P., Zingales, L. (2009) Cultural biases in economic exchange? *Quarterly Journal of Economics*, 124: 1095–1131.
Hefele, P. (1998) *Die Verlagerung Von Industrie- und Dienstleistungsunternehmen Aus der SBZ/DDR Nach Westdeutschland: Unter Besonderer Berücksichtigung Bayerns(1945–1961)*. Stuttgart: Franz Steiner Verlag.
Henning, F. (1993) *Das industrialisierte Deutschland 1914 bis 1992*. Paderborn; München; Wien; Zürich: Schöningh.
Hirsch-Kreinsen, H. (2000) The machine tool industry: new market challenges and the crisis of the traditional German pattern of innovation. In K. Jürgens (ed.) *New Product Development and Production Networks*, pp. 55–65. Berlin; Heidelberg: Springer.
Holmes, T. J. (2010) Structuralist, experimentalist, and descriptive approaches to empirical work in regional economics. *Journal of Regional Science*, 50: 5–22.
Holmes, T. J., Stevens, J. (2002) Geographic concentration and establishment scale. *Review of Economics and Statistics*, 84: 682–690.
Ifo Institute for Economic Research, Sakura Institute of Research. (1997) *A Comparative Analysis of Japanese and German Economic Success*. Tokyo: Springer.
Javorcik, B. S. (2004) Does foreign direct investment increase the productivity of domestic firms? *American Economic Review*, 94: 605–627.
Kahneman, D., Knetsch, J. L., Thaler, R. H. (1991) Anomalies: the endowment effect, loss aversion, and status quo bias. *Journal of Economic Perspectives*, 5: 193–206.
Kerr, W. (2008) Ethnic scientific communities and international technology diffusion. *Review of Economics and Statistics*, 90: 518–537.
Kerr, W., Kominers, S. (2010) Agglomeration forces and cluster shapes. NBER Working Paper 16639.
Klepper, S., Thompson, P. (2006) Submarkets and the evolution of market structure. *RAND Journal of Economics*, 37: 861–886.
Labuske, K., Streb, J. (2008) Technological creativity and cheap labour? Explaining the growing international competitiveness of German mechanical engineering before World War I. *German Economic Review*, 9: 65–86.
Laske, G. (1995) *Eine Musterbranche stürzt ab*. Bremen: Donat.
Lazear, E. (1999) Culture and language. *Journal of Political Economy*, 107: S95–S126.
Lee, K. (1996) The role of user innovation of machine tools: the Japanese case. *Research Policy*, 25: 491–507.
Marshall, A. (1920) *Principles of Economics*. London: MacMillan and Co.
Marx, T. (1979) Technological change and the structure of the machine tool industry. *MSU Business Topics*, 27: 41–47.
Mazzoleni, R. (1997) Learning and path-dependence in the diffusion of innovations: comparative evidence on numerically controlled machine tools. *Research Policy*, 26: 405–428.
Melitz, M. (2003) The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71: 1695–1725.
Menon, C. (2009) The bright side of gerrymandering: an enquiry on the determinants of industrial agglomeration in the United States. Working Paper.
McFadden, D. (1973) Conditional logit analysis of qualitative choice behavior. In P. Zarembka (ed.) *Frontiers in Econometrics*. New York: Academic Press.
Okubo, T., Picard, P. M., Thisse, J. F. (2010) The spatial selection of heterogeneous firms. *Journal of International Economics*, 82: 230–237.
Overman, H., Puga, D. (2010) Labor pooling as a source of agglomeration: an empirical investigation. In E. Glaeser (ed.) *Agglomeration Economics*. Chicago, IL: University of Chicago Press.
Rauch, J., Trindade, V. (2002) Ethnic chinese networks in international trade. *Review of Economics and Statistics*, 84: 116–130.
Richter, R., Streb, J. (2011) Catching-up and falling behind: knowledge spillover from America to German machine tool makers. *Journal of Economic History*, 71: 1006–1031.
Rosenthal, S., Strange, W. (2001) The determinants of agglomeration. *Journal of Urban Economics*, 50: 191–229.
Rosenthal, S., Strange, W. (2003) Geography, industrial organization, and agglomeration. *Review of Economics and Statistics*, 85: 377–393.

Rosenthal, S., Strange, W. (2004) Evidence on the nature and sources of agglomeration economies. In V. Henderson, J.-F. Thisse (eds) *Handbook of Regional and Urban Economics*, vol. 4, pp. 2119–2171. Amsterdam: North-Holland.
Rosenthal, S., Strange, W. (2010) Small establishments/big effects: agglomeration, industrial organization and entrepreneurship. In E. Glaeser (ed.) *Agglomeration Economics*. Chicago, IL: University of Chicago Press.
Rotemberg, J., Saloner, G. (2000) Competition and human capital accumulation: a theory of interregional specialization and trade. *Regional Science and Urban Economics*, 30: 373–404.
Roy, R. (2003) Technology strategy, capabilities, and the survival of the United States machine tool manufacturers, 1975–1995. Dissertation, University of Pittsburgh.
Roy, R., McEvily, S. K. (2004) Incumbent survival during market fusion in maturing industries. In J. Baum, A. McGahan (eds) *Advances in Strategic Management*, vol. 21. Amsterdam: Elsevier Science.
Schmitt, K., Rattinger, H., Oberndörfer, D. (1994) District Data (Censuses 1950–1987). GESIS Data Archive, Cologne. ZA2472 Data file Version 1.0.0, doi:10.4232/1.2472.
Schwab, G. (1996) *Die Entwicklung der deutschen Werkzeugmaschinenindustrie von 1945–1995*. Master Thesis, University of Erlangen-Nürnberg, revised version edited by VDW, Frankfurt.
Sciberras, E., Payne, B. D. (1985) *Machine Tool Industry. Technical Change and the International Competitiveness*. Harlow, Essex: Longman.
Spolaore, E., Wacziarg, R. (2009) The diffusion of development. *Quarterly Journal of Economics*, 124: 469–529.
Verband Deutscher Maschinen- und Anlagenbau e.V. (Various years) *Wer baut Maschinen*. Frankfurt/Main: Hoppenstedt Wirtschaftsverlag GmbH.
Verein Deutscher Werkzeugmaschinenfabriken e.V. (2005) *The German Machine Tool Industry in 2004*. Frankfurt/Main: Verein Deutscher Werkzeugmaschinenfabriken e.V.
Wieandt, A. (1994) Innovation and the creation, development and destruction of markets in the world machine tool industry. *Small Business Economics*, 6: 421–437.

Appendix

A simple representation of firm optimization under the conditions identified for the machine tool industry is $p \bullet g(n) \bullet f(l) - w(n) \bullet l - c$, where $f(l)$ is a concave production technology in the labor input l and c is a fixed cost of operation (both specific to a firm). The size of the industry in the local area is n. We in turn discuss each element of this model. First, due to the export nature of the industry and relatively small size of firms, the price of output p is determined by national or international product markets and is exogenous to the local area. The records suggest demand from Europe was very strong and with limited price competition and perhaps sensitivity. Second, the function $g(n)$ is a reduced-form expression of agglomeration economies that is increasing in n. The function $w(n)$ similarly represents the impact of greater local industry size on input prices. Depending upon the underlying model, local industry growth may raise productivity due to agglomeration economies, raise input prices due to resource competition in the local area or both. Until the 1970s, Germany was at full employment. Workers were also spatially fixed, especially expellee labor, to a first approximation. Thus, increases in n likely raised local wage costs. Third, firms have heterogeneous productivity $f(l)$ due to specialized products, technology levels, managerial capabilities and similar. The best evidence (e.g. observed firm product counts, growth of relocating firms) would also suggest moderate scaling capacity. Finally, the firms face fixed cost of operations. Fixed costs are evident in the substantial exports (Melitz, 2003), patenting and similar innovations and the factors above. Shut-down conditions for incumbents (participation constraints) and first-order conditions for optimal firm size depend upon

the relative strengths of these effects. Thus, the firm's economics appear to include a relatively flat demand curve, a supply curve with a substantial upward slope for the short- and medium-run and fixed costs that operating efforts must exceed. Our evidence and these economic features suggest that incumbent displacement due to Schumpeterian competition may have occurred, but that the push on local resources caused by the new entrants may have been the more important factor in incumbent closure. This may have been because the unit economics of production became unprofitable. More likely, operating returns could no longer meet the fixed costs of production. Greenstone et al. (2010) and Acemoglu et al. (2012) provide a more extended discussion of this theoretical backdrop. Okubo et al. (2010) model sorting of firms by efficiency across areas with different market potential. Our analysis does not consider endogenous sorting as incumbent locations are fixed and the location choice models suggest relocating firms did not factor market sizes (much less future market potential) into their decisions.